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To this day no clear-cut definition of the term *species* exists in the science of biology. Yet every biologist as he observes living nature—and particularly the practical farmer, the agriculturist dealing with plants, animals or microorganisms—is struck first of all by the fact that all interconnected organic nature consists of separate, qualitatively distinct forms. For instance, in practical agriculture it is self-evident that the horse, the cow, the goat, the sheep, etc., and wheat, rye, oats, barley, carrots, etc., are separate, qualitatively distinct forms of animals and plants, respectively. The same thing is true of the wild animals and plants in free nature that environs us. Everybody can distinguish between the oak, the birch and the pine, for instance, as separate and distinct forms.

It is of such separate forms of plants, animals and also microorganisms, as has already been stated, that interconnected living nature consists. These forms of organisms, which do

not interbreed under the ordinary conditions of life that are normal for them or when they interbreed do not produce normally fertile offspring, i.e., forms which are physiologically incompatible, are *species*.

In practical farming, and still more so in free nature, there are many cases where the same name is applied to forms, i.e., species of plants and animals, which, although closely related, are known to be separate and distinct and ordinarily not to interbreed. For instance, ordinary soft wheat, durum wheat, one-grained wheat, emmer wheat and others are all called wheat. Besides the dandelion proper, several other separate and distinct forms, i.e., species, which ordinarily do not cross are also called dandelion. Therefore, in order to draw lines of demarcation between the concepts of these forms, i.e., species, a binomial Latin nomenclature was long ago introduced into the systematics of botany and zoology by *Linnaeus* (1707-78). Thus *Triticum vulgare* is common (soft) wheat, *T. durum*—durum wheat, *T. monococcum*—one-grained wheat, etc. The first part of the designation, the noun, for instance "wheat" (*Triticum*), is the generic name common to all closely related species which in practice or science (in systematics) constitute

one genus. The second part of the designation—the adjective, for instance, "common" (*vulgare*), or "durum" (*durum*)—serves to describe the precise form, the species of the plant or animal.

In practice, when only one species of plant or animal is dealt with, species are called only by their generic names, such as wheat, pine, etc., or horse, sheep, goat, etc. If several closely related species are dealt with in practice, either both names are given: common wheat (*Triticum vulgare*) or durum wheat (*T. durum*), or one of the species is called by its generic name. For instance, common (soft) wheat is designated as wheat and the other species are called by different names; thus *T. dicoccum* may be called emmer.

The very structure of living nature, consisting, as it does, of groups of species similar in many respects yet at the same time separate, delimited, distinct, not interbreeding under ordinary conditions of life, suggested to naturalists ages ago that species originate from other species, that closely related species have much in common and that this which they have in common and which indicates that they are connected in origin is what characterizes them as a genus. Hence living nature itself

dictated to science the binomial nomenclature of species.

Before the advent of Darwinian biology a metaphysical, antiscientific view of *species* prevailed. *Species* were considered *invariable and by no manner of means interconnected in origin and development.* It was argued that no species could have descended from another species, that a separate act of creation had brought each species into existence independently of all the others.

Lamarck, and more particularly Darwin with his theory of evolution, utterly refuted the false assertion of the metaphysical biologists that species are eternal and fixed and that they originate independently of each other.

Darwin in his doctrine of evolution demonstrated that plant and animal forms, species, originate from each other. He thus supplied the proof that living nature has its history, its past, present and future. This is one of the immortal services performed by Darwin's theory.

But Darwinism is based on one-sided and continuous[1] evolutionism. Darwin's theory of evolution proceeds from a recognition of quan-

[1] The Russian original has *plosky* (literally—flat).—*Tr.*

titative changes only: it refuses to take cognizance of the compulsory, law-governed nature of transformations, of transitions from one qualitative state to another. Yet without the conversion of one qualitative state into another, without the genesis of a new qualitative state within the old, there is no development but only increase or decrease of quantity, only what is usually called growth.

Darwinism firmly established in the science of biology the idea that organic forms have their origin in other such forms. However, development in living nature was conceived of by Darwinism as only a continuous, unbroken line of evolution. In biological science—precisely science and not practice—species therefore ceased to be considered as real, separate qualitative states of living nature.

Thus, in his *Origin of Species,* Darwin wrote:

"From these remarks it will be seen that I look at the term species as one arbitrarily given, for the sake of convenience, to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual

differences, is also applied arbitrarily, for convenience's sake."[1]

K. A. Timiryazev wrote to the same effect: "Variety and species represent merely a difference in time. No line of demarcation is conceivable here."[2]

Thus, according to the theory of Darwinism, there should be no natural border lines, no discontinuity between species in nature.

According to evolutionism the development of the organic world may be reduced to mere quantitative changes, without anything new being born within the old, without the development of a new quality, a different totality of properties. This theory holds that so great an interval of time is required for one species to arise from another that the entire history of the human race has not been long enough for the emergence of one species from another to be observed.

After all, organic nature has been in existence for aeons of time. One would therefore suppose that this was ample time for a new species to arise from an old and that as a result of such prolonged changes the appearance, the

[1] Darwin, *The Origin of Species,* London 1901, p. 39.
[2] К. А. Тимирязев, *Сочинения*, т. VII, Сельхозгиз, 1939 г., стр. 97.

birth of new species should be observable by now.

But the same theory declares that actually there should be no dividing line between the new, nascent species and the old, procreating species, for which reason it is supposed to be altogether impossible to observe the generation of a new species within an old one.

In spite of the theory of gradualness throughout, which recognizes no break in development, no transition from one quality to another, and which therefore asserts that there can be no boundaries between species, such boundaries do exist in actual fact, and every naturalist has long been fully aware of this. Therefore Darwinism was forced to invent so-called intraspecific competition, intraspecific struggle, to explain the gap between species. According to this theory all intermediate forms, which, it is maintained, completely filled the gaps between the species and thus constituted an unbroken gradation of forms in organic nature, dropped out in the process of the struggle as being less adaptive.

Thus Darwin had recourse to the reactionary, pseudoscientific Malthusian doctrine of intraspecific struggle to gloss over the obvious

incongruity between evolutionism and the real development of the plant and animal world. This struggle is supposedly called forth by the fact that always in nature more individuals of a given species are born than the conditions available for their existence permit. This is the basis on which Darwin built his so-called theory of divergence, i.e., divergence of characters, the appearance of breaks of discontinuities in the continuous range of organic forms, as a result of which easily distinguishable groups—species of plants and animals—are supposed to have arisen. Consequently, boundaries, breaks between closely related species, came about, according to Darwinism, not as a result of qualitative changes or the emergence of qualitatively new groups of organisms—species of plants or animals—but in consequence of a mechanical dropping out, of a mutual extermination of forms which are qualitatively indistinguishable and constitute an unbroken series.

This explains why all adherents of continuous evolutionism arrive at the conclusion that *species* in theory *are not a result of the process of development of living nature* discovered by science and practice but a convention employed for convenience in classification.

Thus a palpable contradiction has always existed and still exists between the theory of evolution and reality, i.e., the development of organic nature. Darwinism could therefore only explain somehow or other the development of the organic world. But the explanation given could not serve as an effective theoretical basis for practical transformation, could not supply the theoretical foundation for a planned alteration of living nature in the interests of practical life.

Although unable in his day to overcome Darwinian evolutionism in science,. the eminent biologist K. A. Timiryazev, an ardent fighter against idealism and reaction in science, cleary perceived that species are not conventions but real phenomena of nature. He therefore wrote: "These border lines, these sundered links of the organic chain were not introduced by man into nature but forced upon him by nature. This real fact requires a real explanation."[1]

But no such real explanation could be forthcoming from the standpoint of continuous evolutionism, and Timiryazev himself did not

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[1] К. А. Тимирязев, *Сочинения*, т. VI, Сельхозгиз, 1939 г., стр. 105.

go beyond the erroneous Darwinian statement that this fact was the result of the supposed existence of intraspecific competition.

Only in our time and country, in the land of victorious Socialism, where dialectical materialism, developed in the works of Comrade Stalin, is the dominant world outlook, has it become possible to give a real explanation of real biological facts such as *species*. Kolkhoz-sovkhoz agriculture affords every opportunity for the unlimited development of materialist biological science, of Michurin's teaching—creative Darwinism. I. V. Michurin wrote: "We have as yet no correct exhaustive conception of how nature has created and still incessantly creates innumerable species of plants. At the present time it is of much greater benefit to us to realize that we have entered that stage of our historical development in which we are able personally to intervene in the actions of nature and, in the first place, can *considerably accelerate and numerically increase the form building of new species, and, in the second place, artificially divert the building of their qualities in a direction more advantageous to man.* We must furthermore appreciate the fact that such work, jointly performed by us and nature, represents *progress of the highest order,* of global

significance. This will become evident to all from the results which the development of this undertaking will bring in the future—an undertaking powerfully impulsed by the Revolution that aroused millions of creative minds in the Land of Soviets. For here a considerable portion of the population has been given the opportunity to improve life round about by deliberate action."[1]

Michurin's teaching, creative Darwinism, does not regard development as continuous evolution but as the genesis of a new quality within the old, of a quality that contradicts the old, which undergoes a gradual quantitative accumulation of its peculiar features and in the process of its struggle against the old quality constitutes itself into a new, fundamentally different totality of properties with its own distinct law of existence.

Dialectical materialism, developed and elevated to a new high plane by the works of Comrade Stalin, is the most valuable, most potent theoretical weapon in the hands of Soviet biologists, Michurinists, and this is the weapon they must use in solving the profound prob-

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[1] И. В. Мичурин, *Сочинения*, Сельхозгиз, 1948 г. т. I, стр. 614—615.

lems of biology, including the problem of the descent of one species from another.

In agricultural practice as well as in nature relative but quite definite boundaries between species have always existed. By relative but quite definite specific boundaries we mean that parallel with similarity between species there always exists *specific* distinctness, which divides organic nature into qualitatively distinguishable yet interlocking links, or *species.*

No continuous, unbroken series of forms between species—different, qualitatively definite states of living matter—can be found. This is so not because the intermediate forms in a continuous range have died out as a result of mutual competition, but because there is no such continuity in nature, nor can there be. Unbroken continuity does not exist in nature; continuity and discontinuity always form a unity.

A species is a distinct, qualitatively definite state of living matter. Definite intraspecific interrelations between individuals are an essential characteristic of each species of plant, animal and microorganism. These intraspecific interrelations differ qualitatively from the interrelations between individuals of different species. Therefore *the qualitative difference between intraspecific and interspecific interre-*

lations is one of the most important criteria for distinguishing between species and varieties.

It is wrong to state that a variety is an incipient species and a species a sharply defined variety. For if this erroneous formulation were taken as the starting point it would follow that there is no qualitative difference, no line, between species and varieties and that the species is not a reality existing in nature but something contrived for convenience of classification, for systematics. Here, and of this mention has been made above, lies one of the basic contradictions between the theory of continuous evolutionism and the realities of the organic world. Varieties intermediate between species do not exist, not because these varieties dropped out in the process of an intraspecific struggle but because they never did and do not now arise in free nature.

Varieties are forms of existence of a given species and not steps in its transformation into another species. The profusion of varieties is the result of the many-sided ecological adaptivity of the species concerned; it promotes the well-being of the species and tends to preserve it.

The more varieties within a species and the more diversified its intraspecific populations,

the more certain the species and all its varieties are to thrive, through the agency of, for instance, cross-pollination.

The interrelations between individuals of the same species are, we have said, of a quality different from that of the interrelations between individuals of different species. The term *species* is therefore fundamentally different in biology from other botanical or zoological terms, such as genus, family, and the like.

It can easily be noticed that the interrelations between individuals of different species belonging to the same botanical or zoological genus not only do not promote the well-being of the species concerned but, on the contrary, are competitive, antagonistic. It is therefore usually difficult to find in nature or practical agriculture instances of prolonged coexistence in populations of individuals belonging to different but closely related species, i.e., of the same botanical genus. Joint existence of plant species may frequently be observed, but these species are distantly related, belong to different botanical genera. Joint existence of species of the same botanical genus is possible, however, only if the members of each species are distributed in beds or hills.

Hence the concept *genus* in botany and zoology does not imply ordinary ties of kinship such as intraspecific ties but indicates solely that all the species of any genus have a common origin. The term genus serves to specify morphologically similar but qualitatively distinct species.

In spite of their external similarity the individuals of the different species of a genus do not cross under the living conditions to which they are habituated or when crossed fail to produce normally fertile offspring, i.e., they are physiologically incompatible. Moreover, the interrelations between species of the same genus are competitive, mutually exclusive, as we have already stated.

Species are links in the chain of living nature, stages of qualitative distinctness, steps in the gradual historic development of the organic world.

Botanical and zoological taxonomy includes a number of so-called doubtful species. These are species of which systematists are unable to say whether the diverse plants or animals concerned form one or two species. But such species are doubtful only because these forms are little known or because biologists have found no scientifically objective cri-

terion by which to distinguish species and therefore substitute for such criterion separate characters tentatively accepted for the various species. Proof of this is the fact that in agricultural practice people deal with a variety of animals, plants and microorganisms without a doubt ever arising in the mind of any one as to whether a particular group of plants, animals or microorganisms belongs to one, two or more species. Hence doubtful species exist only in systematics but not in living nature.

Species in a state of nature are separated by specific qualitative differences, by relative but quite definite lines of distinction. These must be found so that specific forms, groups of plants, animals and microorganisms, may be properly delineated, systematized and classified.

Nor is the thesis correct which maintains that the qualitative specific features of species do not for any length of time remain constant. As a matter of fact species of plants, animals and microorganisms exist in nature as long as the conditions necessary for the subsistence of their respective individuals endure.

The prime cause of the appearance of species from other species as well as of intraspe-

cific diversity of form is change in the conditions of life of plants and animals, change in the type of metabolism.

The genesis and development of new species is bound up with such alterations in types of metabolism during the process of development of the various organisms as affect the characteristic features of the species concerned.

This is evidenced by the data obtained during the last few years as a result of research on the problem of speciation in the plant kingdom.

In 1948 V. K. Karapetian observed in this experiments that if 28-chromosome durum wheat (*Triticum durum*) is sown late in the autumn some of the plants are converted rather quickly, in two or three generations, into another species, into 42-chromosome soft wheat (*T. vulgare*).

On the basis of the genetic qualitative heterogeneity of the plant organism's body, a heterogeneity previously established by Michurinist biology, it was decided to search for grains of soft, 42-chromosome wheat in the spikes of experimentally grown durum wheat. As a result, individual grains of soft wheat were quite easily observed in the spikes of du-

rum wheat, i.e., grains of one botanical species were found in the spikes of another species.

When grains of this soft wheat (*Triticum vulgare*) taken from spikes of durum wheat (*T. durum*) were sown, they produced, as a rule, soft-wheat plants. In many districts a careful search will reveal each year the presence of soft-wheat grains in some of the durum-wheat spikes also in ordinary farm fields.

In 1949 a search for rye grains in wheat spikes was instituted in the fields of the foothill districts where winter-wheat crops are frequently found to be adulterated with rye. Until a few years ago scientists did not know the original cause of such adulteration in these districts.

V. K. Karapetian, M. M. Yakubtsiner, V. N. Gromachevsky and a number of other research workers as well as a number of agronomists and students found single grains of rye in durum- and soft-wheat spikes, i.e., in the spikes of two wheat species which grew in the fields of various foothill districts. Over 200 such grains of rye were found in 1949. These grains were sown at the Institute of Genetics of the Academy of Sciences of the U.S.S.R., in an experimental field of the Lenin Academy of Agricultural Sciences of the

U.S.S.R. at Gorki Leninskiye, and at the K. A. Timiryazev Agricultural Academy in Moscow.

Unthreshed spikes of durum and soft wheat were likewise sent to the Lenin Academy of Agricultural Sciences of the U.S.S.R. from the districts mentioned. While they were being threshed at different biological research institutions several persons found some more grains of rye.

From these grains of rye, which had developed in spikes of durum and soft wheat, a diversity of plants was grown. These plants, with few exceptions, were nevertheless typical rye. Only in a very few cases were wheat plants obtained from ryelike grains.

In all the above cases where grains of one species of plant were found in spikes of another species neither the plants themselves nor their threshed spikes showed any signs whatever of being intermediate forms. They seemed to be typical, ordinary spikes of durum or soft wheat. But the internal state of these wheat plants was no longer the usual one, was no longer qualitatively homogeneous in respect to species. This is indicated by the fact that these wheat plants produced not only grains

of wheat but also some few grains of rye, that is, grains of another species.

In 1949 the Lenin Academy of Agricultural Sciences of the U.S.S.R. received samples of oats whose panicles contained single grains of wild oats alongside of the grains of cultivated oats, that is to say, the plants of one species, *Avena sativa*, brought forth individual grains of another species, *A. fatua*. Publications abroad as well as in our country have likewise repeatedly referred to cases where wild oats were found in pure-line oats.

It has been observed year after year when cultivating branched wheat (*Triticum turgidum*) on experimental plots of the Lenin Academy of Agricultural Sciences of the U.S.S.R. and in a number of other localities that admixtures of soft and durum wheat, oats, 2- and 4-rowed barley and also spring rye appear in the crops.

All our observations led us to conclude that the original source of these admixtures was the branched wheat (*Triticum turgidum*) itself.

In 1950 it was discovered in several cases that barley plants which were growing as an admixture in branched-wheat crops had developed from grains which in external appear-

ance could not be distinguished from branched-wheat grains.

In practical farming it has long been assumed and repeatedly asserted that one kind of agricultural plant can be converted or transformed into another, as for instance wheat into rye. A great controversy was waged in print on this subject in our country as early as the first half of the previous century. Therefore the conversion of durum wheat into soft or the conversion of durum and soft wheat into rye would seem by itself to be nothing new. However, all the new facts we have adduced were obtained in a systematic way or as the result of a systematic search.

As regards the past, before our investigation started, the facts were as follows. In fields sown to durum wheat individual plants of soft wheat were discovered. When this wheat was resown the soft-wheat plants multiplied more and more and finally ousted the durum wheat. Similarly, individual rye plants were found amidst winter wheat. When the seeds obtained from crops grown in such fields were resown the rapidly multiplying rye plants pushed out the wheat. But scientists refused as a matter of principle to consider any such discoveries of plants of one species in the stands of other

species as a result of the conversion of one species into another. Legitimate doubts were always voiced. It was not established whether or not the prime cause of this adulteration was ordinary mechanical admixture so frequently met with. There was no assurance that the original seeds really did not contain an admixture of a few seeds of another species, or that seeds of another species had not been carried to the sown field in question by water, wind, birds or some other agency; nor could one be sure that seeds of the admixed breed had not been in the soil of that field for a long period of time, etc.

This explains why it was impossible to prove by facts relating to the past that *the emergence of one plant species from another species* might also be an original source of the various crop admixtures and adulterations, besides their frequent introduction into crops by mechanical means.

All the enumerated objections to the idea of one species giving rise to another become invalid in the cases referred to by us. Individual grains of rye discovered in spikes of wheat which had grown for several generations under definite conditions could not possibly have been introduced into these spikes from

without by either birds or man or in any other way.

These grains of rye were generated by wheat plants and developed in spikes of wheat.

The supposition that these seeds might be of hybrid origin also goes by the board. It is a known fact that wheat can be crossed with rye, though seldom. However, in these cases the product obtained is an obvious rye-wheat hybrid which can readily be distinguished from wheat and rye by its external appearance. Besides, rye-wheat hybrids, as a rule, are self-sterile; they yield no seeds unless they are pollinated with the pollen of one of their parents, preferably the wheat. In the case at hand the grains of rye from the wheat spikes produced ordinary rye plants with normal fertility. The said plants manifested no hybrid properties whatever.

The same applies to the other facts we have mentioned.

The above examples of the generation of particular plant species by others are particularly valuable because analogous cases may be observed any year in suitable fields. Similar results may likewise be obtained by cultivating plants specially sown under experimental conditions for this purpose.

The factual material so far obtained on the problem of species formation concerns the plant world only. We do not yet have the data essential to demonstrate how species are formed in the animal world. But we may rest assured that before long the development of the theory of Michurinist biology will make it possible to accumulate data also for zoological objects analogous to the data taken from the world of plants.

The material available on the problem of speciation in the plant world affords grounds for belief that many, if not all, existing species of plants can arise de novo at the present time, and under suitable conditions repeatedly do arise from other species. Moreover, one plant species may give rise to several species closely related to it. For example, a single species, durum wheat (*Triticum durum*) can produce both soft wheat (*T. vulgare*) and rye (*Secale cereale*).

A change in the environmental conditions essential to the specific nature of the particular organisms sooner or later changes this specificity perforce—certain species originate other species. Under the influence of the changed conditions, which have become deleterious to the natures (heredities) of the organisms of

the plant species growing here, rudiments of bodies of other species more fit for the changed environmental conditions arise and take shape in the bodies of the organisms constituting these species. Such qualitative heterogeneity in the body of a plant organism which is characteristic of various other species may in some cases be detected even by the naked eye.

The appearance under the influence of suitable environmental conditions of specific qualitative heterogeneity in the bodies of plants explains the often repeated creation of some species by others that have long been in existence. When plants of a particular species somehow or other come under the influence of conditions relatively unfavourable for the normal development of the peculiar features of their species, enforced alteration takes place, and rudiments of another species with peculiar features, more in accordance with the new environmental conditions, appear in the plant organisms of that particular species. As they are more responsive to the particular conditions, the isolated specimens of the other species generated within the old species rapidly multiply and are capable under these conditions of extruding the species which gave them birth. If

this goes on in free nature the emergent species will rapidly multiply and completely oust from the habitat the species that gave rise to it.

Things are otherwise in practical agriculture where the plants cultivated are shielded and protected from weed species by agrotechnical methods.

Scientists have long known that many weed species grow only in cultivated fields and that in free nature they not only do not but cannot exist. Thus, if a field overgrown with numerous species of weeds is abandoned, remains uncultivated and unsown, it will soon enough, in about 20 or 30 years, be completely rid of its many weed varieties. Such a field will no longer grow species of weeds but other plant species which are the peculiar product of ordinary unbroken, untilled plots in the particular locality.

Weed species are generated partly by species existing in free nature and partly by cultured plant species. For instance, cultivated oats may give rise to wild oats, one of the worst of weeds.

Not a single plant species at home on virgin soil will, when that soil is broken, find the conditions requisite for its normal develop-

ment. Therefore the species that grew on the virgin soil change sooner or later with greater or less rapidity but with absolute certainty into other species suited to the conditions created by the tilling of the soil. The same takes place with cultivated plants when they encounter unfavourable climatic or agrotechnical conditions. They are also certain to change sooner or later into other species better adapted to these conditions.

Some weed species have long been introduced into cultivation. Rye, for instance, begotten under certain conditions by wheat, is under these conditions a pernicious weed which drives the wheat from the field. In such districts special measures are therefore taken—crop weeding, sorting wheat seeds from rye seeds—to protect wheat at all times from extrusion by rye. In other districts, on the contrary, rye has long been a cultivated plant. The same can be said of soft wheat. It is frequently produced by durum wheat and in that event adulterates it. Durum wheat is therefore protected against such adulteration by weeding the seed crops. Soft wheat, on the other hand, is a crop that man has cultivated for ages.

Many another species of cultivated plants are the products of other cultivated plant spe-

cies. This will explain why no wild, ancestral forms have been found so far for many species of cultivated plants.

Bad agrotechnique, which does not create in the fields the good conditions that cultivated plants require, leads to a deterioration of the nature of these plants with respect to yield and quality of crop. Simultaneously, bad agrotechnique promotes the multiplication of various species of weeds, the seeds and other rudiments of which are to be found in the soil or are introduced into it by badly sorted sowing material. Finally, bad agrotechnique may also create the conditions for the generation de novo, by cultivated plants, of isolated rudiments of a number of weeds.

To ascertain the original sources of the emergence of particular species of weeds and discover the environmental conditions which determine such emergence constitutes a task of paramount importance to agronomic biology. Research work conducted to this end will not only facilitate the control of weeds now existing in the fields but also enable us to preclude the possibility of weed species being brought into existence by other such species or by cultivated plants.

The creation of new conditions for organisms or the withdrawal of these organisms from the action of certain existing environmental conditions makes it possible to produce new plant species useful to practical agriculturists and also to preclude the possibility of generating weed species harmful to agricultural practice.

This is one, but not the only one by far, of the practically important tasks involved in the theoretical elaboration of the problem of speciation.

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